WADC TECHNICAL REPORT 52-159

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DEVELOPMENT AND ACCEPTANCE OF ANTENNA AT-230(XA)/APT AND ANTENNA AT-230/APT

KENNETH E. WILL
AIRCRAFT RADIATION LABORATORY

JUNE 1952

WRIGHT AIR DEVELOPMENT CENTER

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WADC TECHNICAL REPORT 52-159 SECURITY INFORMATION

DEVELOPMENT AND ACCEPTANCE OF ANTENNA AT-203(XA)/APT AND ANTENNA AT-203/APT

Kenneth E. Will
Aircraft Radiation Laboratory

June 1952

RDO No. 112-110

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Inc., Wakefield, Mass.
Oct. 17, 1952 100

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FOREWORD

This report was prepared by Aircraft Radiation Laboratory, Weapons Components Division, Wright Air Development Center, in connection with the design, development, and tests of Antenna AT-230(XA)/APT. Experimental models designed by Aircraft Radiation Laboratory, and development models submitted by Dalmo-Victor Company, San Carlos, California, under Contract No. AF 33(038)-12741, were tested for compliance with Exhibit No. MCREE-715. The applicable Research and Development Order is 112-110, "Antennae, Built-in, Guided Missiles and New Aircraft." The tests described were made by members of the Antenna Design Unit, Advanced Development Branch, Aircraft Radiation Laboratory, under the direction of the Project Engineer, Kenneth E. Will.

ABSTRACT

A résumé of the design, development, and tests of certain helical radiators in recessed cavities is presented. This report covers the original design work performed at the Aircraft Radiation Laboratory and further development of 10 experimental models attributed to the Dalmo-Victor Company in order to improve the electrical and mechanical properties of the antenna. As a result of tests conducted by Aircraft Radiation Laboratory on the experimental models of the AT-230(XA)/APT and development conducted as outlined in the Dalmo-Victor Company final report based on Exhibit MCREE-715, a production model of Antenna AT-230/APT is therefore now available to the Services.

The security classification of the title of this report is UNCLASSIFIED.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

Harry E. McAfee
Lt Col USAF
for DANIEL B. WHITE
Colonel, USAF
Chief, Weapons Components Division

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SECTION I - INTRODUCTION

The purpose was to design, develop and test a cavity-recessed helical antenna in order to determine its acceptability based on requirements outlined in the Electronics Subdivision Exhibit No. MCREE-715, "Antenna AT-230(XA)/APT."

The antenna consists of a hermetically sealed cavity, recessed, flush-mounted, end-loaded helix designated as Antenna AT-230(XA)/APT and operates over a frequency range of from 1000 to 2600 mc. Antenna AT-230(XA)/APT is specified as a zero-drag airborne antenna for use with Radar Set AN/APT-9, which transmits signals in the frequency band from 1000 to 2600 mc. The antenna is connected to the transmitter through a coaxial cable of 52-ohm characteristic impedance. It was designed to meet the requirements of circular polarization and beam width of from 55° to 65° and to have a Voltage Standing Wave Ratio (VSWR) of 2.5 to 1 or less over the complete frequency range.

SECTION II - DEVELOPMENT

EFFECT OF CONDUCTOR DIAMETER

The helices for the first models of this antenna were constructed of 0.101-inch diameter phosphor bronze wire. Extreme difficulty was experienced in keeping the VSWR and Axial Ratio (AR) less than 3.5 to 1 in the 1000 - 2600 mc range. Spacing of the bottom turn from the bottom of the cavity was very critical. Both VSWR and AR characteristics of this antenna were greatly improved when the helix was constructed of one-fourth inch copper tubing. Helices were also constructed of three-eighths inch copper tubing; however no improvement resulted over the one-fourth inch diameter conductor.

EFFECT OF SPACING OF BOTTOM TURN FROM CAVITY

The spacing of the bottom turn of the helix from the bottom of the cavity is still the critical adjustment for the antenna. The variation of input impedance is due almost entirely to the spacing of the first 180° of the helix. The design of the transition from small to large conductor is critical in regard to shape and taper. Each antenna requires special attention to obtain proper adjustment of the bottom turn to meet VSWR specifications. Checks at 1000, 1100, 2000, 2500, and 2600 mc should ensure that all values within the band will satisfy the specifications.

EFFECT OF DIFFERENT END LOADS

Compared with the effect of the diameter of the helix conductor, the type of end loading has a relatively minor effect on VSWR and AR. A number of different load configurations were tested. Most of the helices gave satisfactory VSWR and AR characteristics. One helix constructed of one-fourth inch copper tubing was tested with no end loading. VSWR and AR were within specifications up to 2200 mc; however, at the time this test was carried out, the best spacing of the bottom turn from the cavity had not been determined. Often the effect of different types of loads was marked by the effect of different spacing of the helix first turn. Closer spacing of turns on the end loading coil appeared to improve VSWR and AR at the 2600-mc end. When a solid cylinder was substituted for the loading coil, results were just as good as for closely spaced turns.

EFFECT OF DIFFERENT HELIX DIAMETERS

For the one-fourth inch tube helix the effect of helix diameter was investigated for constant spacing between turns and found to be critical. Helix diameters varying from 2-3/4 inches to 4-1/2 inches produced good VSWR and AR in the 1000 - 2600 mc band. Pattern shape for the different helix diameters was not investigated. The helix diameter selected for final design was chosen because it gave good pattern characteristics even outside the 1000 - 2600 mc band and tended to minimize the problem of meeting specifications on production.

TUNING METHODS

A satisfactory method of tuning consists of sliding a wedge-shaped polystyrene block under the first turn and adjusting its position for optimum results. Standing Wave Ratios outside of the limits of the specifications could be brought in at the expense of slightly raising already low values in other parts of the band. This method of tuning did not produce any noticeable effect on AR.

A second method consists of placing a polystyrene slab one-fourth inch thick inside the bottom of the cavity covering the entire area except under the first 45° of the bottom turn. Antennas which had VSWR's exceeding 2.5 because of improper spacing of the bottom turn could be tuned within specifications throughout the band in all cases. No measurements were made to determine the effects of the slab outside the frequency range. This information on tuning methods is merely stated as a possible means of extending the bandwidth of helical antennas.

SECTION III - TEST PROCEDURES FOR MODEL CAAD-1

Aircraft Radiation Laboratory conducted the following tests on Model CAAD-1 of Antenna AT-230(XA)/APT submitted by the contractor, Dalmo-Victor Company, San Carlos, California.

VISUAL INSPECTION

Upon receipt of Model CAAD-1, the antenna was given visual inspection for defective workmanship, material, and assembly. It was found to be satisfactory.

ELECTRICAL REQUIREMENTS AND TEST

The VSWR throughout the operating frequency range from 1000 to 2600 mc was not to exceed 2.5 to 1 when used in conjunction with a 52-ohm coaxial transmission line. VSWR of the antenna was measured with the antenna mounted on a ground plane having a diameter of five feet. Measurements were made at 50-mc intervals, throughout the frequency range in a location free from interference. The VSWR was determined by use of a Hewlett-Packard 805A measuring line.

The radiation patterns throughout the operating frequency range of 1000 - 2600 mc taken in a plane perpendicular to the ground plane containing the antenna were to be symmetrical, having a maximum intensity of radiation on axis of the helical element. The pattern width between half power points was measured and found to be not less than 50° or more than 65° over the specified frequency range. The radiation pattern measurements were taken with the antenna mounted in a ground plane having a diameter of five feet and were made at 200-mc intervals throughout the operating frequency range in a location free from interference. Average values of $E\phi$ and $E\theta$ patterns were determined in the following planes:

a. The plane perpendicular to the ground plane which contained the antenna and passing through the major axis of the polarization ellipse.

b. The plane perpendicular to the ground plane which contained the antenna and passing through the minor axis of the polarization ellipse.

The on axis voltage axial ratio, defined as the ratio of the major axis to the minor axis of the voltage polarization ellipse when the test antenna is placed on the projected axis of the helix, was not to exceed 2.5 throughout the band of 1000 - 2600 mc. The AR was measured every 200 mc throughout the entire band of frequencies with the antenna mounted on a ground screen having a diameter of five feet. It was determined by rotating a linearly polarized dipole antenna with the plane of the dipole parallel to the ground plane, and the center of the dipole at a distance on the projected axis of the helix. The sense of polarization of the helix was determined by use of two suitable, oppositely sensed, circularly polarized antennas.

A modified UG-98/U Type "LN" connector was used for power input. A test was made to determine compliance with the operating power requirements. A C-W transmitter giving a constant R-F output of at least 150 watts was used as a source.

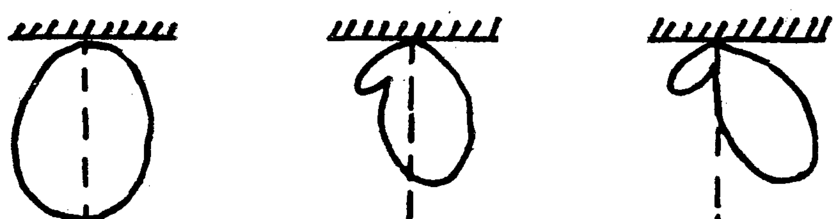
Table I shows VSWR and AR at Lobe Maximum, also AR at Helix Axis. Figure 1 shows the field patterns in the horizontal plane through the helix axis.

TABLE I

ELECTRICAL TEST RESULTS OF MODEL CAAD-1

FREQUENCY MC	VSWR	AR LOBE MAXIMUM	AR HELIX AXIS
900	12.0		
1000	3.8		10.0
1100	1.2		1.37
1200	1.7	1.25	1.02
1300	2.4		
1400	2.9		
1500	1.7	1.25	2.0
1600	1.3		5.0
1700	2.1		1.25
1800	2.1		3.0
1900	1.6	1.42	1.5
2000	1.4		1.66
2100	2.6	2.0	
2300	3.9	3.2	10.0
2500	3.5		

Horizontal Plane Through Helix Axis



1000 - 1800 Mc   1800 - 2200 Mc   2200 - 2600 Mc

Figure 1 - Field Patterns, Model CAAD-1

MECHANICAL TESTS

The antenna was submitted to mechanical tests to determine the effects of vibration, altitude, and temperature per Specification AN-E-19, and to test for leakage by immersion.

The antenna was vibrated with frequency varying between 10 and 55 cycles per second at an amplitude of 0.03 inches, total excursion 0.06 inches. Application of vibration was for 90 minutes in each of three mutually perpendicular directions.

The antenna was placed in a chamber and the pressure varied for five cycles from 29.92 (normal pressure) to 3.4 inches of mercury (50,000 ft).

The antenna was subjected to five temperature cycles consisting of 85°C for 60 minutes followed by 15 minutes at 25°C, then -65°C for 60 minutes and 15 minutes at 25°C.

The gas-filled antenna was submerged in a wetting bath inside the chamber, and the pressure lowered to 3.4 inches of mercury for one hour, or until leakage occurred.

Mechanical test results of Model CAAD-1 showed that vibration, altitude, and thermocycle tests caused no apparent damage. The immersion test first showed leakage at 8000 feet and increased above that altitude. The leakage did not cease until the altitude was lowered down to the 2000-feet level. Because of this failure Model CAAD-1 was rejected and returned to the Dalmo-Victor Company.

SECTION IV - TEST PROCEDURES FOR MODELS CAAD-2 THROUGH CAAD-11

Models CAAD-2 through CAAD-11, inclusive, were submitted by Dalmo-Victor Co. for tests and acceptance. Table II shows the VSWR and AR of the models. Figure 2 shows the field pattern of the models. The field patterns shown are given as the over-all average of all 10 models CAAD-2 through CAAD-11. Deviations from the patterns shown were negligible.

MECHANICAL TESTS OF MODELS CAAD-2 THROUGH CAAD-11

Mechanical tests of altitude, vibration, temperature cycling and submersion were carried out on all models as performed on Model CAAD-1.

ANALYSIS OF RESULTS

All antennas passed all tests except Model CAAD-4, which showed slight leakage in the submersion test at 40,000 feet. Leakage occurred at one spot of the front cover. The antenna was removed from the chamber, the bolts holding the cover were tightened slightly, and the antenna was given a second test. During the second test the antenna showed no leakage. All antennas were again checked for VSWR, suffering no effects from the mechanical tests. All 10 models CAAD-2 through CAAD-11 were accepted.

TABLE II
VSWR AND AR OF ANTENNAS, MODELS CAAD-2 THROUGH CAAD-11

Frequency	CAAD-2		CAAD-3		CAAD-4		CAAD-5		CAAD-6		CAAD-7		CAAD-8		CAAD-9		CAAD-10		CAAD-11	
MC.	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR	VSWR	VAR
1000	2.4	8.0	3.2	3.0	1.9	2.9	1.8	3.5	2.1	3.0	1.64	1.9	1.42	1.9	1.14	1.9	1.42	1.8	1.16	1.14
1050	2.3	4.7	1.8	4.0	2.2	2.6	2.8	3.3	2.6	3.0	2.1	2.0	1.80	1.8	1.41	1.6	1.68	2.0	1.50	1.9
1100	3.4	3.5	2.3	2.5	2.5	2.7	3.4	2.4	3.6	2.9	2.3	1.8	1.97	1.7	1.60	1.5	1.86	1.6	1.58	1.5
1150	2.2	2.7	1.9	3.1	1.9	2.5	2.4	2.8	2.9	2.8	2.3	1.5	1.90	1.6	1.61	1.6	1.90	1.5	1.51	1.3
1200	1.5	3.5	2.3	2.6	1.4	2.0	1.3	2.4	1.6	2.1	2.1	1.2	1.49	1.4	1.34	1.5	1.70	1.3	1.37	1.2
1250	2.2	2.8	1.8	2.4	2.1	2.2	2.5	1.9	2.9	2.3	1.88	1.3	1.21	1.6	1.19	1.3	1.53	1.3	1.21	1.3
1300	2.4	2.7	2.2	2.3	2.3	2.4	2.7	2.8	3.7	2.5	1.59	1.2	1.07	1.7	1.06	1.4	1.30	1.4	1.07	1.4
1350	2.4	2.2	2.4	2.0	2.2	1.9	2.9	2.7	3.7	3.0	1.50	1.2	1.20	1.5	1.19	1.4	1.16	1.4	1.14	1.3
1400	2.0	1.7	2.3	2.0	1.8	1.9	2.4	2.4	3.0	2.6	1.50	1.3	1.31	1.5	1.31	1.4	1.19	1.4	1.23	1.6
1450	1.4	2.0	1.8	1.7	1.4	1.9	1.9	2.5	2.4	2.6	1.60	1.2	1.48	1.4	1.39	1.4	1.27	1.2	1.33	1.4
1500	1.2	1.9	1.3	1.9	1.1	1.9	1.4	2.0	1.5	1.9	1.74	1.1	1.55	1.2	1.50	1.2	1.43	1.2	1.43	1.4
1550	2.2	1.8	1.3	1.9	1.6	1.9	2.4	1.9	2.0	1.9	1.87	1.1	1.52	1.5	1.49	1.2	1.51	1.3	1.44	1.1
1600	2.2	2.0	2.2	2.0	1.9	1.5	2.6	1.9	2.8	1.9	1.99	1.2	1.53	1.2	1.52	1.2	1.51	1.3	1.48	1.3
1650	1.4	2.3	1.8	1.6	1.1	2.0	1.3	1.8	1.4	1.9	2.2	1.1	1.45	1.1	1.60	1.2	1.48	1.2	1.40	1.4
1700	2.5	2.4	1.5	2.0	2.1	2.3	2.4	2.3	2.3	1.9	1.99	1.4	1.41	1.7	1.44	1.5	1.55	1.4	1.37	1.4
1750	2.5	2.2	2.2	2.2	2.4	2.0	3.0	-	3.2	-	1.61	1.4	1.37	1.5	1.24	1.6	1.34	1.8	1.31	1.6
1800	2.5	1.8	3.2	2.1	2.5	2.0	3.0	2.2	3.6	3.7	1.22	1.8	1.28	1.9	1.18	2.1	1.07	2.2	1.16	2.2
1850	1.8	2.4	2.7	2.4	1.8	1.7	3.0	2.4	3.2	3.3	1.25	1.8	1.38	1.7	1.21	2.4	1.35	2.1	1.26	2.3
1900	1.4	2.2	2.1	2.5	1.6	2.1	1.9	-	2.4	2.7	1.58	1.5	1.79	1.8	1.48	1.5	1.68	2.5	1.53	2.0
1950	2.4	2.4	1.2	2.1	2.3	-	1.9	-	1.5	1.6	1.61	1.3	2.0	1.6	1.94	1.7	1.61	1.8	1.71	1.5
2000	2.9	1.4	2.5	1.7	2.6	1.7	2.9	1.8	2.9	1.8	1.60	1.2	2.2	1.9	2.2	2.0	1.80	1.2	2.1	1.5
2050	1.8	2.8	2.8	-	2.3	-	3.0	-	3.4	-	1.73	1.5	2.1	2.1	2.1	2.4	1.71	1.5	2.1	1.5
2100	2.9	1.2	1.9	1.4	1.8	-	1.9	2.0	1.9	1.6	1.60	1.5	1.9	1.6	1.85	1.8	1.53	1.3	1.87	1.5
2150	3.8	1.6	2.2	-	3.2	-	3.0	-	2.7	1.2	1.46	1.6	1.81	1.4	1.68	1.7	1.43	1.5	1.62	1.2
2200	3.8	2.1	3.2	1.7	3.7	1.7	3.5	-	3.8	-	1.48	1.6	1.80	1.1	1.65	1.2	1.49	1.1	1.59	1.2
2250	2.3	2.0	3.5	-	3.1	-	3.6	1.7	3.8	-	1.58	1.4	1.98	1.1	1.81	1.3	1.67	1.1	1.84	1.1
2300	2.7	1.5	2.9	1.9	3.0	-	3.2	-	3.6	1.6	1.82	2.0	2.0	1.3	2.0	1.4	1.80	1.3	1.82	1.2
2350	2.5	1.6	2.8	2.0	2.6	2.2	2.9	-	2.9	1.7	1.88	1.4	1.99	1.3	1.81	1.4	2.0	1.5	1.79	1.6
2400	2.4	2.4	2.5	2.0	2.2	2.0	2.8	1.5	2.4	1.9	1.64	1.4	2.0	1.7	1.80	1.5	1.70	1.9	1.77	1.6
2450	2.8	2.4	3.0	-	3.0	-	2.5	-	2.5	-	1.78	1.4	2.1	1.5	1.85	1.7	1.55	1.4	1.72	1.7
2500	2.8	3.0	2.7	1.8	3.3	2.0	2.9	-	2.6	2.8	1.95	1.6	2.1	2.0	1.95	2.0	1.66	1.2	1.75	1.9
2550	2.6	1.5	2.6	1.4	2.7	2.4	1.8	-	3.2	-	1.92	2.0	2.1	2.0	2.0	2.7	1.74	1.3	1.54	2.1
2600	3.0	2.0	2.1	2.3	2.5	1.3	2.0	1.3	2.1	1.6	1.97	2.4	2.2	2.0	2.3	2.3	1.66	2.0	1.88	2.2

The difference in conductor diameter should be noted; in Models CAAD-2 through CAAD-6 the 0.101-diameter phosphor bronze wire was used; in Models CAAD-7 through CAAD-11 the 1/4 inch diameter copper tubing was used.

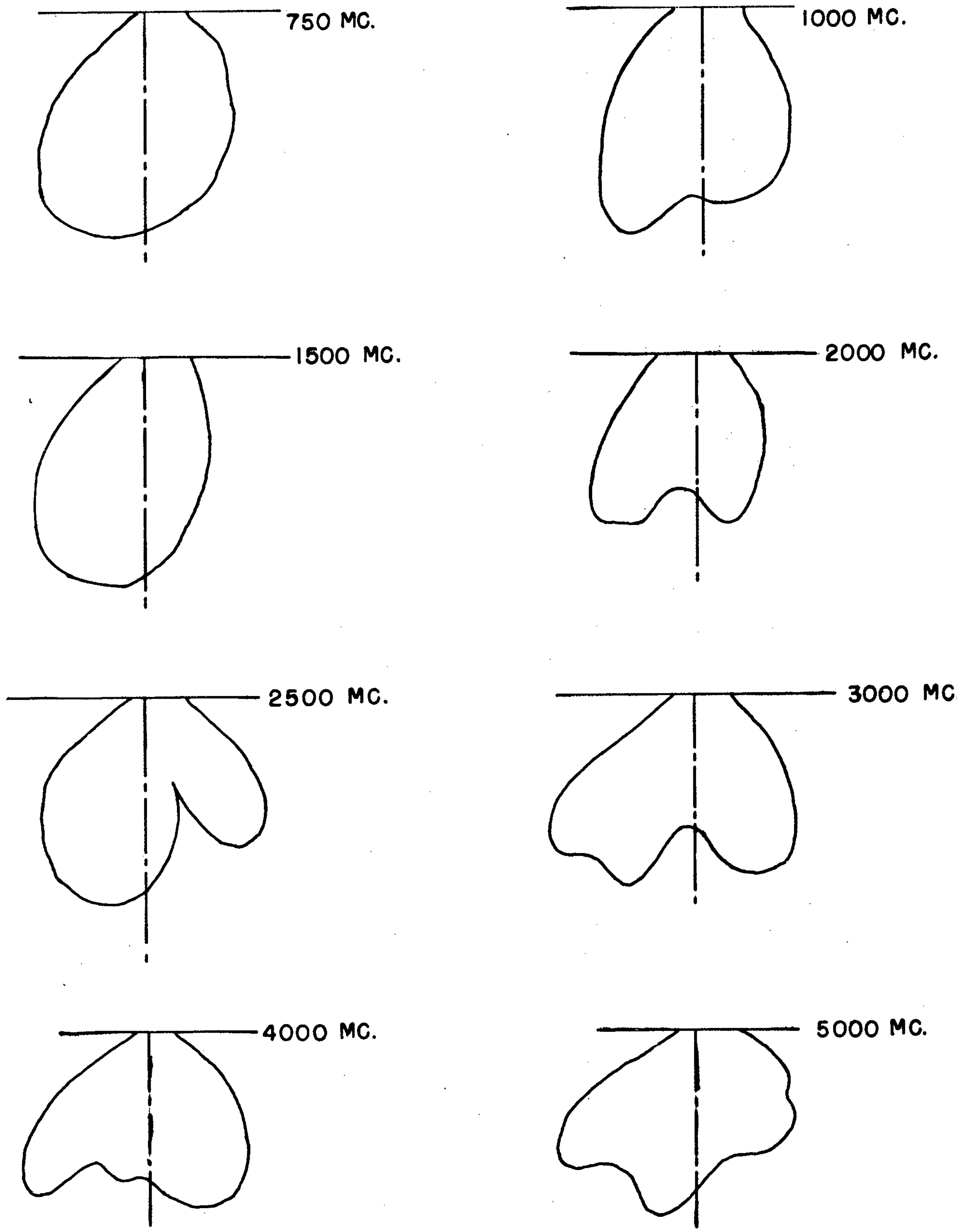


Fig. 2 Field Patterns for Antenna AT-230(XA)/APT
Horizontal plane through helix axis-Models CAAD-2 through CAAD-11

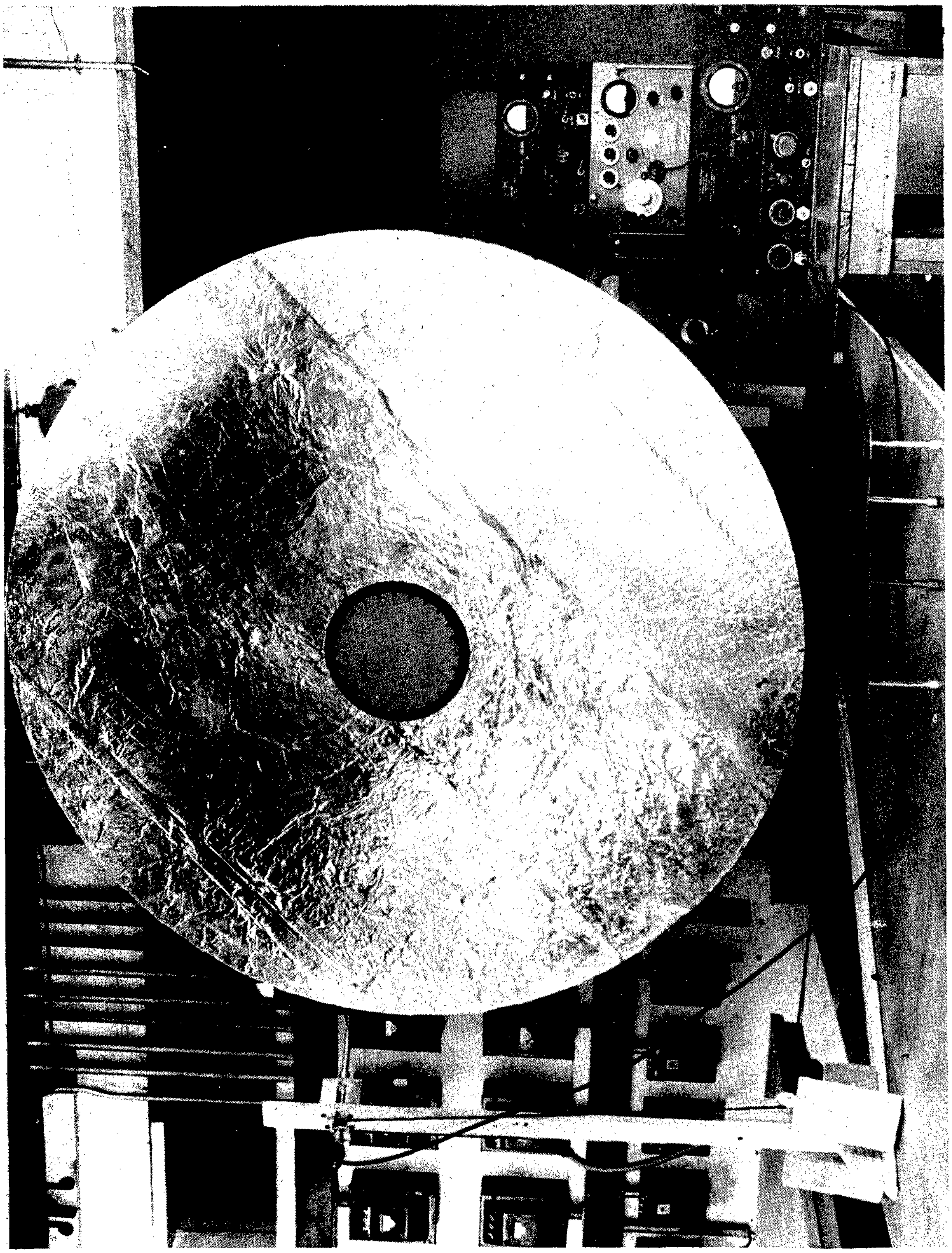


Fig. 3 Test Setup - Front View - Dalmo Victor Company

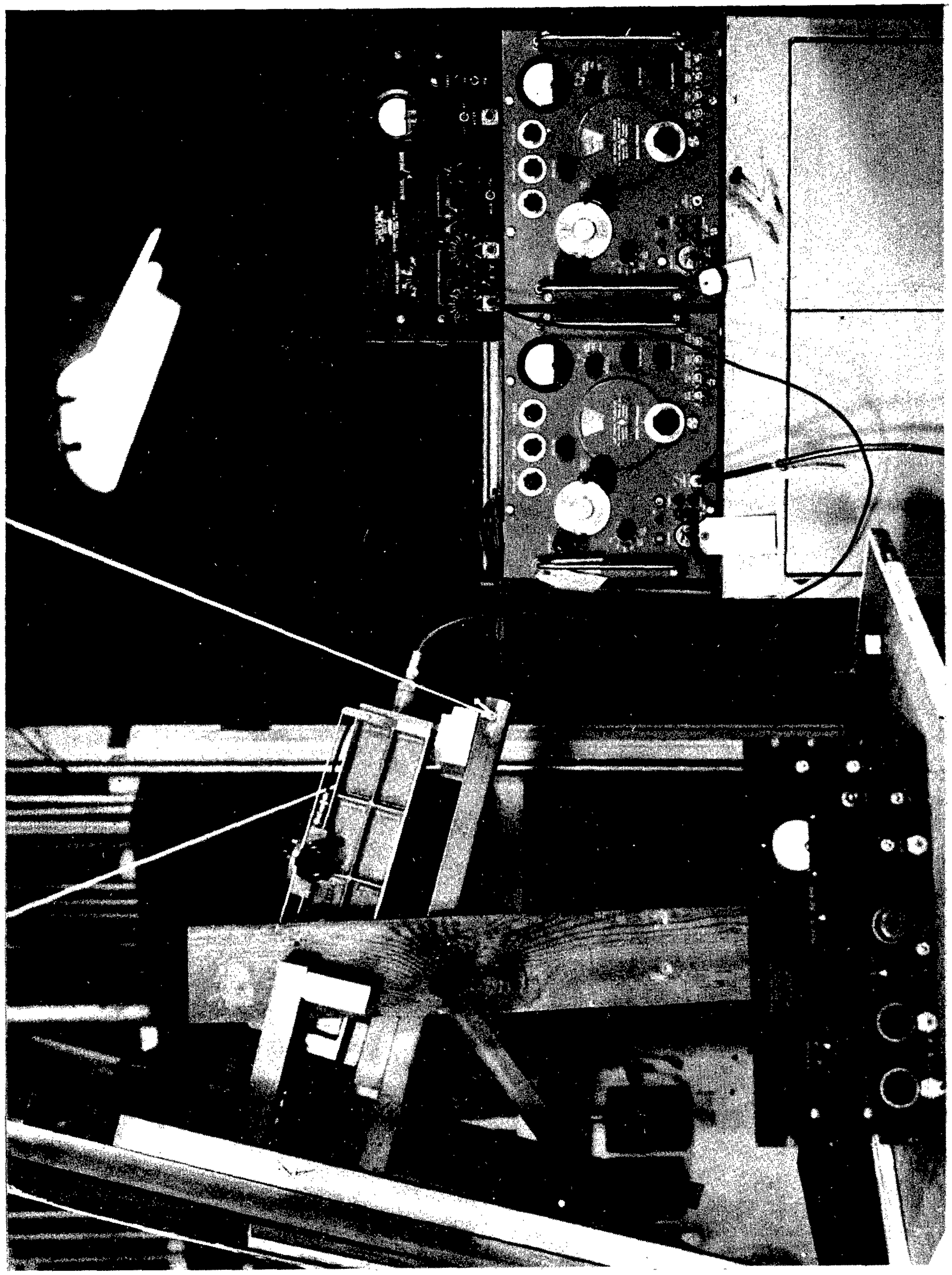


Fig. 4 Test Setup - Side View - Dalmo Victor Company

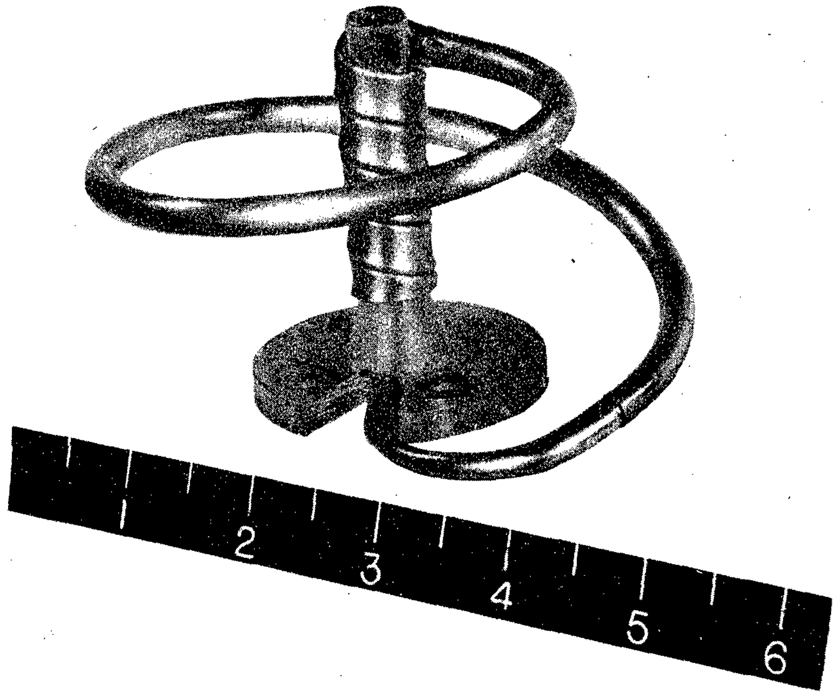


Fig. 5 Helix Element and Standard - AT-230(XA)/APT

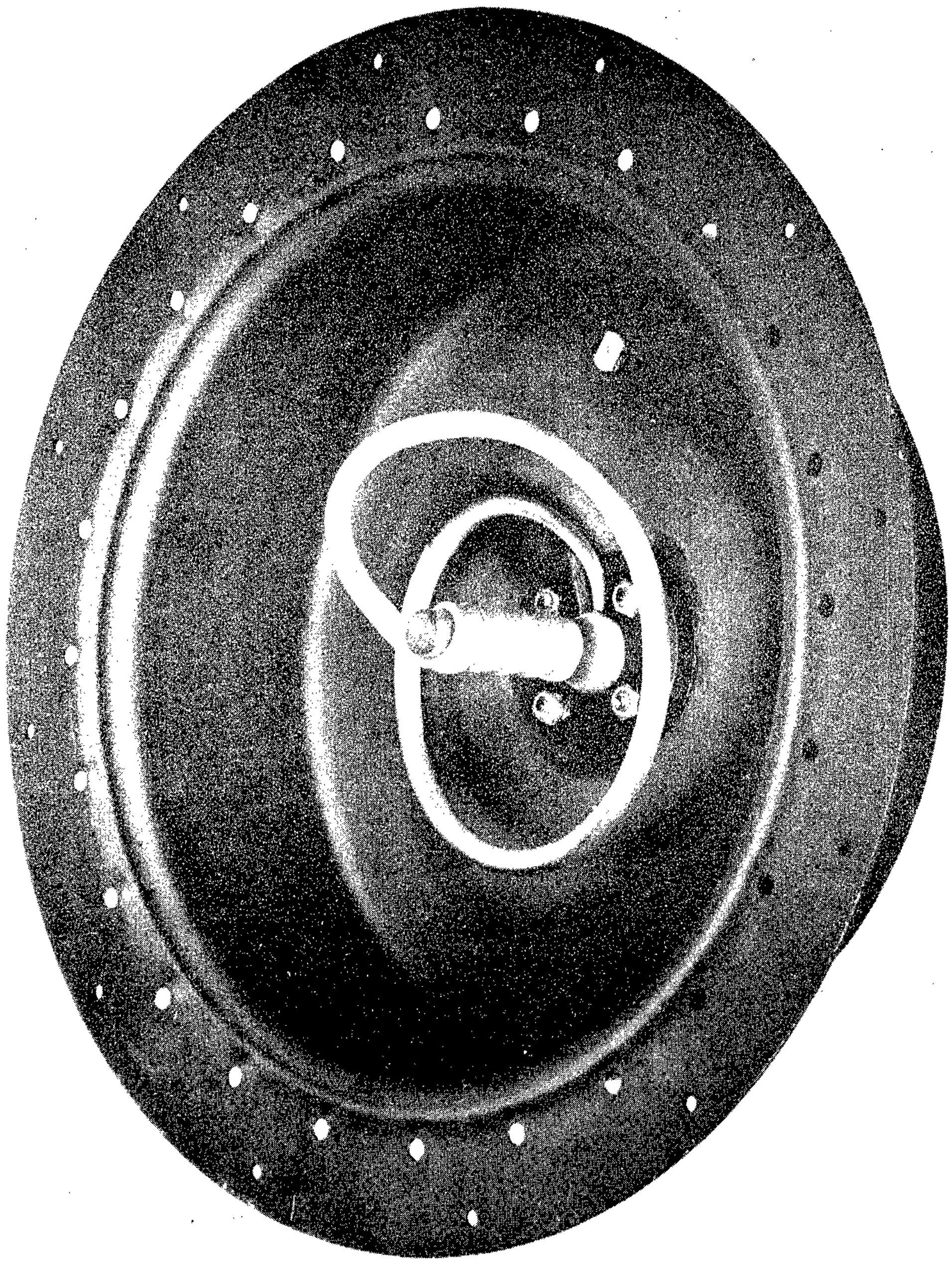


Fig. 6 Antenna AT-230(XA)/APT - Diagonal View

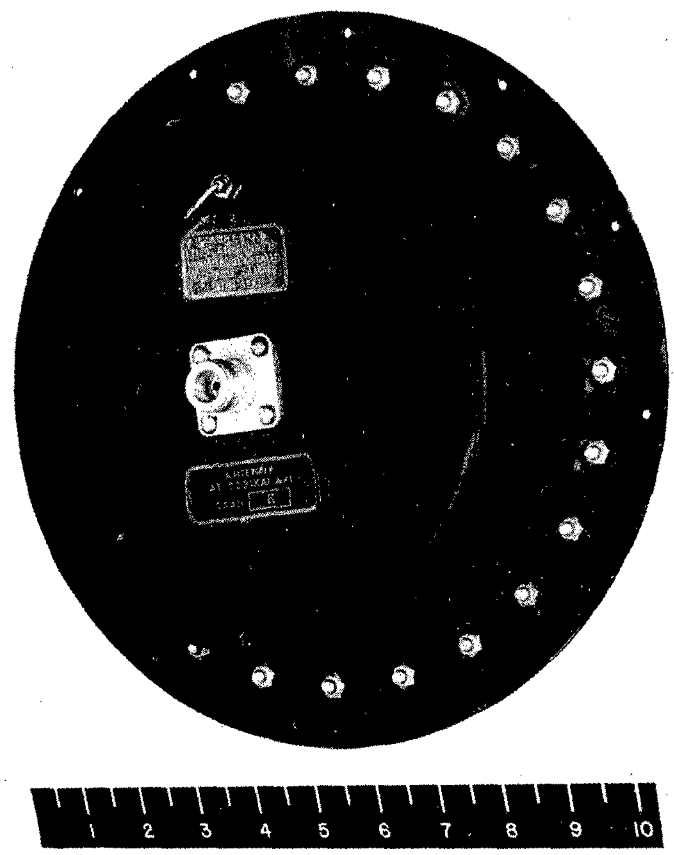


Fig. 7 Antenna AT-230(XA)/APT - Rear View

SECTION V - SUPPLEMENTARY DATA PREPRODUCTION ANTENNA AT-230/APT

The report thus far has covered data and analysis of experimental antenna model AT-230(XA)/APT. The following is supplementary data for the design of an antenna which includes necessary modifications for production purposes. This antenna is designated as "Antenna AT-230/APT." Figures 8, 9, and 10 show the construction of the modified antenna. (Modifications of cavity and cover to provide for omission of the "O" ring are not shown in Figure 9.) Test results for this model are included and discussed.

MODIFICATIONS

RF CONNECTOR

A UG-921/U connector, manufactured by Diamond Manufacturing Company, Wakefield, Massachusetts, is used in the preproduction model. The connector is modified by shortening the center conductor by 1/8 inch and threading. A gusset plate is added to the back of the cavity as a receptacle for this connector.

HELIX

The helix has been modified to eliminate the transition piece from small to large conductor. The use of the new type connector made this modification possible. The gusset plate is bored to make the one-fourth inch copper tubing of the helix the center conductor of a 50-ohm coaxial line. The end of the helix conductor is filled with hard solder, drilled and tapped to thread into the center conductor of the modified UG-921/U connector.

The antenna may be tuned by varying the number of turns the connector is threaded into the gusset plate, thereby varying the spacing of the first turn of the helix from the bottom of the cavity.

COIL SUPPORT

The coil support is modified to make room for the one-fourth inch conductor and the holes are countersunk to take flat head machine screws. It is also shortened 1/16 inch.

CAVITY

The cavity has been modified to omit the "O" ring retainer.

"O" RING

The "O" ring has been omitted on this model, since one unit failed the 50,000-foot altitude test because of leakage around the cover. Sealing of the cover is accomplished by applying Minnesota Mining Company EC-801 cement to the surface to be sealed.

COVER

The material for the cover of this model has been changed to "Lamicoid Type GMG," manufactured by Mica Insulator Company, Schenectady, New York, since the laminated Fiberglas grade FFP-41 formerly made by Formica Insulation Company, Cincinnati, Ohio, is no longer manufactured. The Formica Insulation Company recommends Grade FF-55 which complies with Specification MIL-P-15037A, Type GMG. An investigation is being made for a material having lower RF losses.

COVER RETAINER

The retainer for the coil support was modified to permit the cover to set down on the support 1/8 inch further. This is to accommodate expansion of cavity at high altitudes.

TESTS

PRESSURIZATION TEST

The unit was sealed around the connector and cover with EC-801 cement and pressurized with three pounds per square inch gauge of nitrogen gas. It was then submerged under water and given the 50,000-foot pressure chamber test. No leaks were observed.

VOLTAGE STANDING WAVE RATIO

Test results show that the maximum VSWR occurring in the range of from 1000 to 2600 mc is 2.1. This is at 2600 mc. The next highest is 1.68 at 2550 mc and the average over the 1000 - 2600 mc range is 1.32. These characteristics are superior to those of experimental models in that the VSWR previously obtained was 1.53 for Model CAAD-11. Note, VSWR specifications are met from 800 to 4000 mc.

AXIAL RATIO

AR data was taken for the dipole pickup located both on the projected helix axis and at the lobe maximum. This data was extended from 750 to 4000 mc. If AR data measured at the lobe maximum is considered, specifications are met from 900 to 4000 mc. Considering AR data measured on the projected helix axis, specifications are met from 900 to 4000 mc with the exception of one point at 1800 mc where the AR rises to 3.0

TEST RESULTS

Table III contains test results submitted by Dalmo-Victor Co., and Table IV indicates results determined by Aircraft Radiation Laboratory.

TABLE III

DALMO VICTOR TEST RESULTS - AT-230/APT PREPRODUCTION MODEL

FREQ. MC	VSWR	AR LOBE MAX.	AR HELIX AXIS	FREQ. MC	VSWR	AR LOBE MAX.	AR HELIX AXIS
750	10.0	5.8	5.6	2450	1.36	1.3	2.4
800	2.7	4.5	3.5	2500	1.38	1.5	2.3
850	1.68	3.9	1.8	2550	1.68	1.5	2.3
900	1.48	2.0	1.9	2600	2.1	1.8	2.0
950	1.26	1.5	1.7	2650	2.3	-	2.4
1000	1.24	1.8	1.5	2700	2.1	-	2.0
1050	1.34	1.3	1.4	2750	1.98	1.5	2.1
1100	1.45	1.4	1.5	2800	2.2	1.5	2.6
1150	1.49	1.3	1.4	2850			
1200	1.44	1.3	1.3	2900	2.4	1.2	1.9
1250	1.23	1.2	1.2	2950			
1300	1.14	1.1	1.1	3000	2.3	1.6	1.7
1350	1.04	1.3	1.2	3050			
1400	1.06	1.05	1.2	3100	2.3	1.2	1.2
1450	1.13	1.2	1.3	3150			
1500	1.21	1.3	1.3	3200	2.5	1.3	1.4
1550	1.28	1.2	1.4	3250			
1600	1.36	1.2	1.1	3300	2.6	1.6	1.05
1650	1.39	1.5	1.6	3350			
1700	1.27	1.3	2.0	3400	2.6	1.9	1.5
1750	1.24	1.4	1.6	3450			
1800	1.13	1.5	3.0	3500	2.5	2.2	-
1850	1.06	1.3	-	3550			
1900	1.25	2.3	-	3600	2.3	1.4	-
1950	1.40	2.3	1.4	3650			
2000	1.57	1.4	1.6	3700	2.4	-	-
2050	1.62	1.3	1.5	3750			
2100	1.58	-	-	3800	2.7	-	-
2150	1.35	-	-	3850			
2200	1.09	1.5	1.6	3900	2.4	1.4	-
2250	1.12	1.4	1.5	3950			
2300	1.19	1.2	2.0	4000	2.6	-	-
2350	1.19	1.3	2.0				
2400	1.30	1.1	1.5				

TABLE IV

VSWR - TEST RESULTS OF AT-230/APT PREPRODUCTION MODEL
OBTAINED AT AIRCRAFT RADIATION LABORATORY

FREQ. MC	VSWR	FREQ. MC	VSWR	FREQ. MC	VSWR
1000	1.16	1550	1.10	2100	1.61
1050	1.26	1600	1.10	2150	1.45
1100	1.27	1650	1.18	2200	1.22
1150	1.30	1700	1.14	2250	1.08
1200	1.30	1750	1.16	2300	1.1
1250	1.16	1800	1.1	2350	1.16
1300	1.01	1850	1.04	2400	1.14
1350	1.04	1900	1.08	2450	1.14
1400	1.06	1950	1.16	2500	1.2
1450	1.1	2000	1.32	2550	1.4
1500	1.12	2050	1.45	2600	1.7
				2650	1.8

SECTION VI - CONCLUSIONS

From test results of the experimental model AT-230(XA)/APT, as well as of the preproduction model AT-230/APT which included all necessary modifications for ease of production, the helical antenna described in this report meets all the necessary requirements to ensure proper radiation performance of any signal emitted by Radar Set AN/APT-9. The antenna meets both electrical and mechanical performance requirements as covered in military specifications and therefore is recommended for operational use on USAF aircraft.

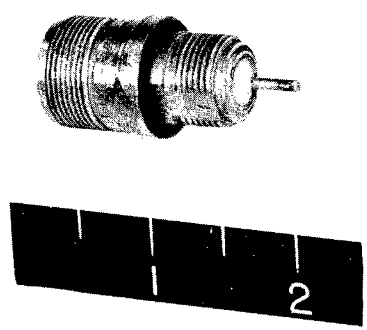


Fig. 8 Connector Receptacle UG-921/U

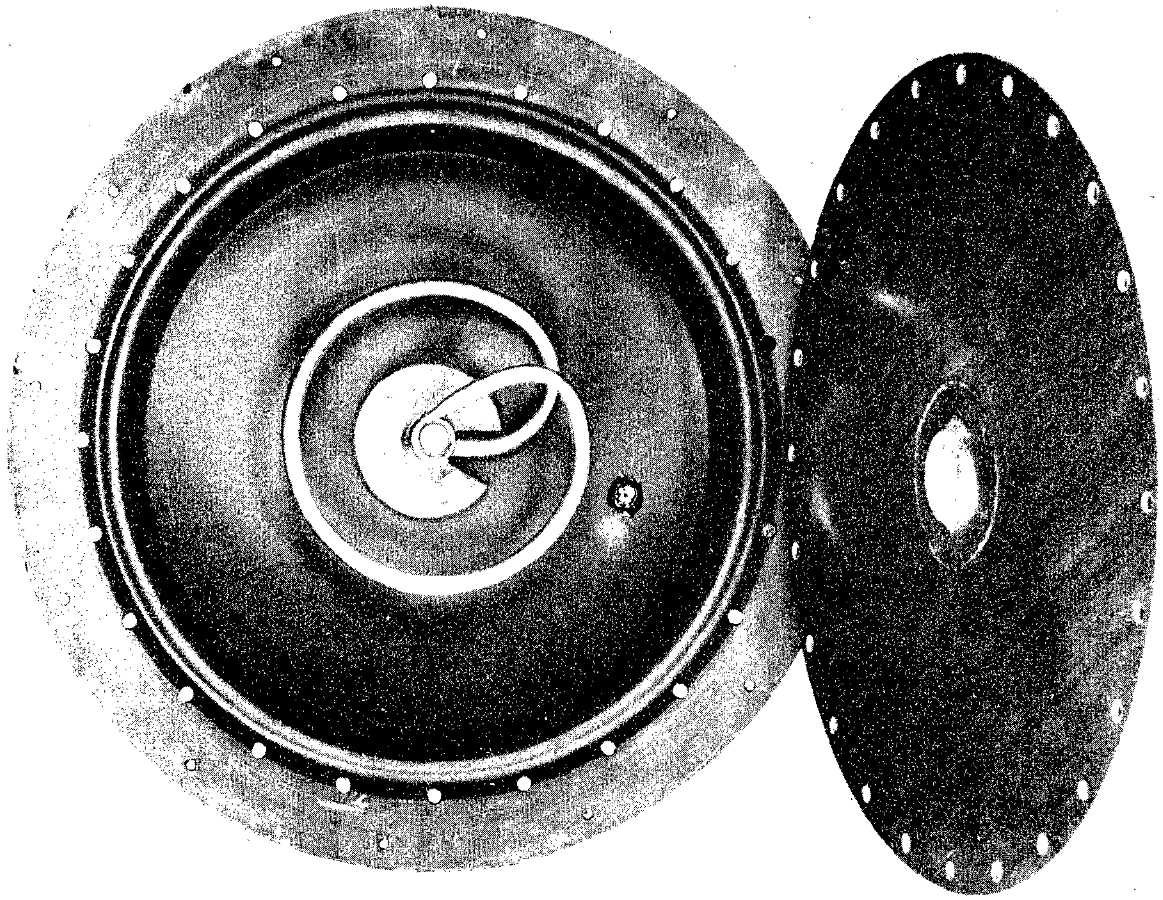


Fig. 9 Antenna AT-230/APT Preproduction Model, Front View

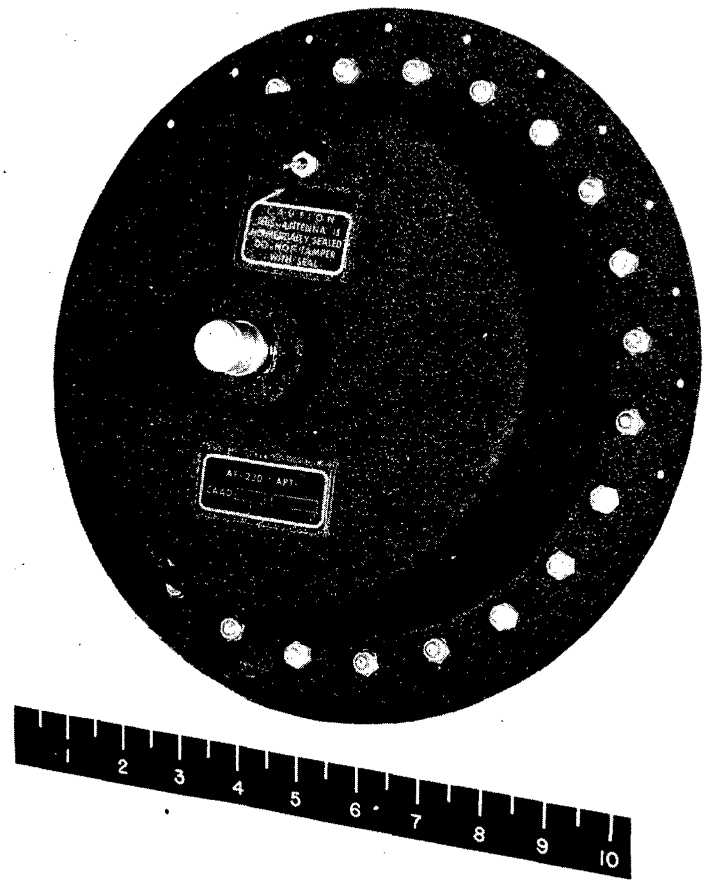


Fig. 10 Antenna AT-230/APT Preproduction Model, Rear View

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